Growth and Demography in Turkey: Economic History vs. Pro-Natalist Rhetoric

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Abstract. This paper projects the effects of exogenous fertility changes in Turkey on the age structure of population and the standards of living using a semi-reduced-form model of economic growth and demographic change. Both the technological progress and the fertility rate are endogenous. The calibrated version of the model delivers three important results: First, technological progress will be the major source of economic growth in Turkey in the upcoming decades. Second, even with a non-declining saving rate, the population aging will result in a growth slowdown since technological progress is not fast enough in Turkey. Third, even under an increasing rate of technological progress, a permanent upward shift in fertility levels would imply, relative to the benchmark, a significantly lower level of output per capita, a remarkably higher level of dependent population, and a persistently lower share of the working-age population for many decades. These results suggest that the priority of policy-makers in Turkey should be technological progress. The pro-natalist rhetoric, even if it proves to be strong enough to persuade the people of Turkey to have more children in the near future, does not have any economic significance.

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1. Introduction

Population aging is an inevitable outcome of the demographic transition during which both fertility and mortality rates decline. Since the labor force is a key input into production and innovation technologies, an aging population implies an increasing level of dependency to the working-age population. This is expected to result in serious damage to the well-being of individuals in any country if technological progress is not fast enough and if the systems of health care, education, and social security are not ready for the increasing burden of dependency.[1]

The population aging problem seems to be the most dramatic in some European countries, and most of these countries implement pro-natalist population policies. In 2009, according to the United Nations (2011), 19 European countries—where the total fertility rate for the 2005-2010 period is less than 1.5—view fertility to be "Too Low," and 17 of these 19 countries want to "Raise" fertility.[2]

Pro-Natalism is, in fact, an old ideology that favors the expansion of populations or, in a nationalist context, the population of a particular nation. Its origins are found within the teachings of the Abrahamic religions, and pro-natalism is also associated with attempts to use eugenics for nationalist and imperialist ends.[3]

Growth and demography in Turkey, as in many other developing economies, have patterns that are similar to those experienced earlier by today's developed economies. Real output per capita has a long-run growth trend, technological progress—either through innovation or through adoption or through sectoral reallocation—is not a negligible source of economic growth, and fertility and mortality rates are decreasing. Turkey's population is already on the earliest stages of its aging path. According to the United Nations (2011), Turkey's total fertility rate of 2.2 for 2005-2010 is the highest across Europe, and the *view* and the *policy* on fertility in 2009 are, respectively, "Satisfactory" and "Maintain."

Nothing is surprising about a satisfactory fertility rate to be maintained since population policy in Turkey switched from being pro-natalist to being anti-natalist in the mid-1960s.[4] However, pro-natalism now "strikes back" with Prime Minister Erdoğan's rhetoric of *at least three children* declared by himself publicly in various occasions since March 7, 2008.[5] Erdoğan urges married couples to have at least three children to keep Turkey's population young and to avoid the problem of population aging.

This paper constructs a semi-reduced-form model of economic growth and demographic change for Turkey to analyze the effects of *exogenous* upward shifts in fertility rates. The main purpose is simply to inquire whether the pro-natalist rhetoric of

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[1] Clark et al. (1978) and Weil (1993) provide detailed surveys of the economics of population aging. See Goldstein (2009) for an introduction to population aging from a demographer's point of view.

[2] The rise of pro-natalism in Europe is also evident from the European Commission's (2005, p. 10) *Green Paper* that indicates "the return to demographic growth" as an essential priority.

[3] See Glass (1936) and Moskoff (1980), respectively, for discussions on the oppressive pro-natalist policies of Mussolini's Italy and the socialist Romania from an economic perspective.

[4] See Levine and Üner (1978) for a discussion of the anti-natalist population policy formation in Turkey.

[5] Hürriyet Arşiv, "Erdoğan: Give birth to at least three children," `http://goo.gl/KaMYF`, March 7, 2008.

Prime Minister Erdoğan would have any economic significance in the near future if, *in the extremely unlikely case*, this rhetoric proves to be sufficiently strong to persuade the people of Turkey to have more children.

Prime Minister Erdoğan's rhetoric of at least three children has not caused a flow of quantitative studies on growth and demography in Turkey, most possibly, for two reasons: First, economists generally believe that not mere rhetorics but various sorts of scarcities and incentives govern the human behavior. There is no need, then, to care about the effects of baby booms until a serious pro-natalist change in *population policy formation* takes place in Turkey. Gürsel et al. (2010), studying the determinants of having more than the desired number of children in Turkey, for example, consider three children *a dream*. The second reason is that an increase in fertility rates—due to the worries about the working-age population—does not really make sense from an economist's point of view basically because Turkish economy does currently have a record of high unemployment with jobless growth, low labor participation rates, and a large pool of *unskilled* labor. Oyvat (2012), for example, indicates that a policy in Turkey that targets higher fertility but no increase in labor participation would actually be supporting the increase of the unskilled labor force. Sayan (2013)—considering all the arguments put forward by the supporters of the pro-natalist rhetoric—notes the importance of long-run economic growth and rightly argues that an upward deviation in fertility rates would not be a solution to the social security problems in Turkey.[6]

This paper aims at providing some quantitative results on the effects of the pronatalist rhetoric.[7] The model economy constructed features endogenous technological progress and endogenous fertility. According to the unified growth theory and the new economic history literatures, both are essential in understanding the very long-run evolution of economic growth and demographic change.

For Turkey, Ismihan and Metin-Ozcan (2009) and Çiçek and Elgin (2011) conclude that the growth of total factor productivity (TFP) is an important source of economic growth, and the time-series evidence reported by Utku-Ismihan (2012) indicate that the growth of an aggregate knowledge variable is positively associated with economic growth over the period 1963-2010. The results obtained by Saygılı et al. (2005) show that the aggregate TFP in Turkey has a secular growth trend after the

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[6] See Alper et al. (2012) for a detailed analysis of the effects of population aging on the sustainability of the social security system in Turkey. In another comprehensive study, Tansel and Hoşgör (2010) study the effects of demographic change in Turkey on several sectors of the economy.

[7] The only study that has a similar purpose is that of Açıkgöz (2012) who estimates that a return to higher fertility in Turkey would necessitate a remarkably higher growth rate of the stock of physical capital.

early 1980s.[8] The data on the number of enterprises and the share of R & D workforce in Turkey further indicate that the reported growth in the aggregate TFP might be explained by the *logic* of the second-generation Schumpeterian models that stress the vertical (or R & D) and the horizontal (or Entry) dimensions of endogenous technological progress.[9] This is not to say that Turkish economy is innovating in the same way as the United States or Germany, and much of the observed increases in the number of enterprises and the share of R & D workforce may be translating into economic growth through technology adoption. Assuming that both innovation and adoption occur through R & D and Entry, the model economy of this paper is a semi-reduced-form version of a typical second-generation Schumpeterian model with some other extensions.[10]

The model economy treats fertility in reduced-form as a function of output per capita. This is in line with the economic approach of Becker (1960, 1965), Becker and Lewis (1973) and their followers that builds upon the quality-quantity trade-off; the time-cost of reproduction increases with income, and parents choose to have fewer but healthier and more educated children.[11] Regarding the historical fertility decline in Turkey, Farooq and Tuncer (1974) and Behar (1995), for example, stress the roles of social and economic development. The results summarized by HÜNEE (2009) show that economic prosperity, education levels, and the use of modern contraceptives are inversely related with fertility rates. Selim and Üçdoğruk (2005) study the quality-quantity trade-off in Turkey and find supporting evidence.

This paper is most directly related with the literature on the effects of population aging on economic growth. The early pessimistic view that focuses only on physical capital accumulation and life-cycle savings builds upon the implication that the aging of population would result in a decrease in the aggregate saving rate. The work by Cutler et al. (1990) concludes, for the United States, that population aging would neg-

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[8] The growth accounting exercises by Altuğ et al. (2008, p. 395)—who consider the roles of various factors such as institutions and human capital accumulation—show that "output growth in Turkey is primarily due to capital accumulation, not TFP growth." İmrohoroğlu et al. (2012)—who construct a two-sector model for Turkey—argue that both non-agricultural and agricultural TFP growth have remained lower than those of peer countries with similar macroeconomic policies and records.

[9] The prominent second-generation Schumpeterian models include those of Young (1998), Peretto (1998), Aghion and Howitt (1998, Ch. 12), and Dinopoulos and Thompson (1998). In the models of this type, the total R & D workforce in the economy is thinly distributed among innovating firms that expand through entry.

[10] Yeldan (2012) constructs a dynamic general equilibrium model to understand the economic growth in Turkey within a framework that incorporates R & D investments.

[11] This, of course, is not to mean that the decline in mortality measures is not important for the fertility decline. The long-run evidence recently documented by Herzer et al. (2012) for a large set of countries do neither reject the role of mortality nor reject the role of output per capita. Since the mortality transition itself depends on technological progress and increasing level of investments in health care in the long run, the reduced-form approach of this paper indirectly associates the role of declining mortality with the fertility transition.

atively affect economic growth only in the very long run. Futagami and Nakajima (2001) develop a simple model to show that, with an increasing life-span, the effects of aging on the aggregate saving rate and growth would be positive. Bloom et al. (2003) provide evidence in favor of such a positive relationship between life expectancy and the saving rate. The simple calibration exercises reported by Scarth (2009) indicate only a very modest decline in living standards. Irmen (2009) focuses on the channel of innovation induced by the relative abundance of physical capital and offers optimistic conclusions regarding the economic growth. Lee and Mason (2010) and Prettner et al. (2012) study the human capital channel of endogenous growth and argue that the aging of population does not necessarily lead into growth slowdowns. Elgin and Tumen (2012), also paying attention to human capital, show that economic growth can coexist with a declining population. The model developed by Bruce and Turnovsky (2012) indicates that, if higher life expectancy increases the retirement age as well, both economic growth and the saving rate responds positively to population aging. Overall, the recent literature that takes technological progress into account seems to have overturned the early pessimistic view of a negative aging-saving relationship. If population aging negatively affects economic growth in the upcoming decades in the developed and the developing world, this effect will be minor basically due to the sustained technological progress (see Bloom et al., 2010).

The main results of this paper on growth and demography in Turkey, following from a calibrated version of the model, are the following:

- Technological progress will be the major source of economic growth in Turkey until the end of this century.
- Even with a non-declining saving rate, the population aging in Turkey will result in a growth slowdown since technological progress is not fast enough.
- Even under an increasing rate of technological progress throughout the century, a permanent upward shift in births per capita to its 1995 level—occurring in 2015—would imply a significantly lower level of output per capita, a remarkably higher level of dependent population, and a persistently low level of the share of the working-age population for many decades.

These results suggest that the priority of policy-makers in Turkey should be technological progress. The pro-natalist rhetoric, even if it proves to be strong enough to persuade the people of Turkey to have more children in the near future, does not have any economic significance.

The paper is organized as follows: The next section presents a discussion on the long-run aspects of growth and demography to build some background. Section 3, after explaining why a semi-reduced-form approach is followed, introduces the model economy. Section 4 describes the data and the strategy used to achieve the benchmark calibration. Section 5 on the quantitative experiments presents the main results. Section 6 discusses these results with special emphases (*i*) on the issue of intergenerational conflict, (*ii*) on the congestion effects of a very high level of population, and (*iii*) on the pro-natalist policies. Section 7 concludes with some remarks and is followed by acknowledgements and the list of references.

2. Growth and Demography in the Long Run

2.1. From Stagnation to Growth

Economic growth and demographic change have remarkable long-run regularities across countries: For a very long period of time before modernity, living standards around the globe were low and stagnant, technological progress was slow and sporadic, fertility and mortality levels were high, and small and isolated populations were young. Today, in countries where the transition to modernity first started, living standards are high and growing, technological progress is fast and sustained, fertility and mortality levels are at historically lowest levels, and populations are significantly older.

The literature on *unified growth theory*, after the influential model of Galor and Weil (2000), explicitly deals with the questions of (*i*) why today's developed economies did stagnate for several millennia before the Industrial Revolution and (*ii*) how the transition from stagnation to growth really occurred.[12] These ambitious questions are located within a framework that unifies the distant past with the present, and the long-run processes such as the demographic transition are explicitly studied by the unified growth theorists.[13]

The main lessons of the unified growth theory stress the importance of the Malthusian checks during the early stages of economic development and the role of *latent* variables that evolve behind the scenes during the stagnation era until the very evolution of them causes some changes in incentives. Due to these changes, the economy gradually leaves the stagnation trajectory to move to the growth trajectory

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[12] See Galor (2005, 2010) for two surveys of this literature.

[13] The neoclassical growth models take the technological progress exogenous while what explains economic growth *is* the technological progress. The endogenous growth models use either the Marshallian externalities in physical and human capital accumulation or the Schumpeterian creative destruction to explain why and how technology advances. However, these are the models designed to explain *growth*, and only the poverty trap models with multiple steady-state equilibria leave some room for the stagnation equilibrium in the long run. However, the poverty trap models explain either the stagnation or the growth but not the both. The unified growth theory unifies the mechanisms that lead to the stagnation of several millennia followed by an endogenously occurring gradual transition to the regime of sustained growth.

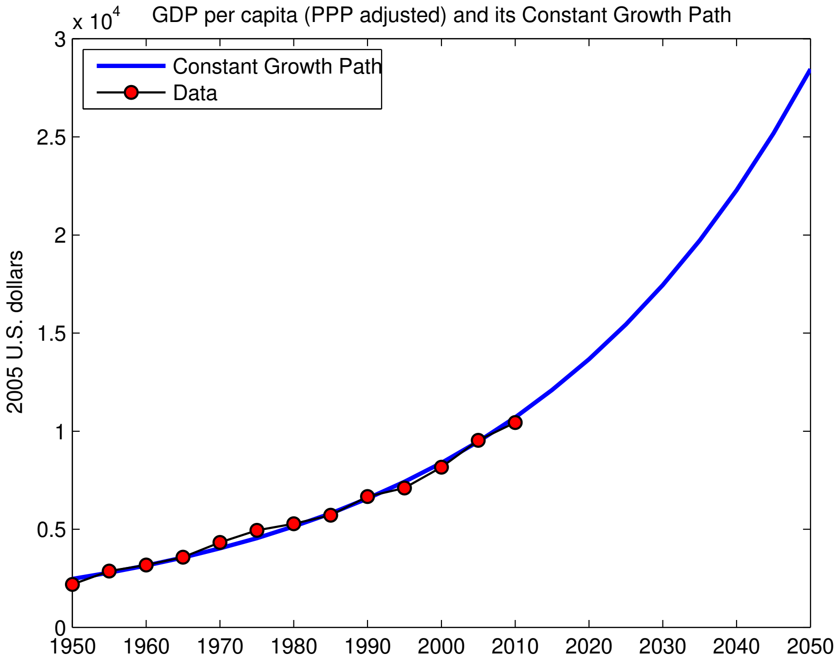

Figure 1: GDP per capita and its Constant Growth Path in Turkey: 1950-2050

Purchasing power parity converted GDP per capita series, measured in 2005 U.S. dollars, is from the PENN World Tables 7.1 of Heston et al. (2012). The constant growth path is implied by a five-year percentage growth rate of $g = 0.13$ via $y_t = y_0(1+g)^t$.

without an exogenous shock.[14]

The earliest theoretical models of the transition from stagnation to growth have either focused on human capital accumulation as the engine of growth—e.g. Lucas (2002)—or treated technological progress in reduced-form as a function of population level—e.g. Galor and Weil (2000). In response, some theorists have offered models that explicitly account for the roles of business formation and the purposeful investments in the advancement of technology while the emphasis on the demographic transition is preserved. Two recent contributions in this stream are of Desmet and Parente (2012) and Peretto and Valente (2011). Both models focus on the role of the market size for firms in triggering purposeful innovation, and the latter explicitly deals with

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[14] In the canonical model of Galor and Weil (2000), for example, the key latent variables are productivity and population: The rate of technological progress positively depends on the level of population, and a low level of population during the early stages of economic development implies a very slow rate of technological progress. In time, however, population very slowly expands and this leads to an increasing rate of technological progress. In these early stages, adults choose to increase their fertility due to the relaxing preventive check. The resulting higher rate of population growth then translates into faster technological progress that at some point leads the adults to choose to invest more into the quality of their children due to the skill-bias in technology. The resulting dynamics of this canonical model overlap, in many respects, with the entirety of a typical transition to modernity.

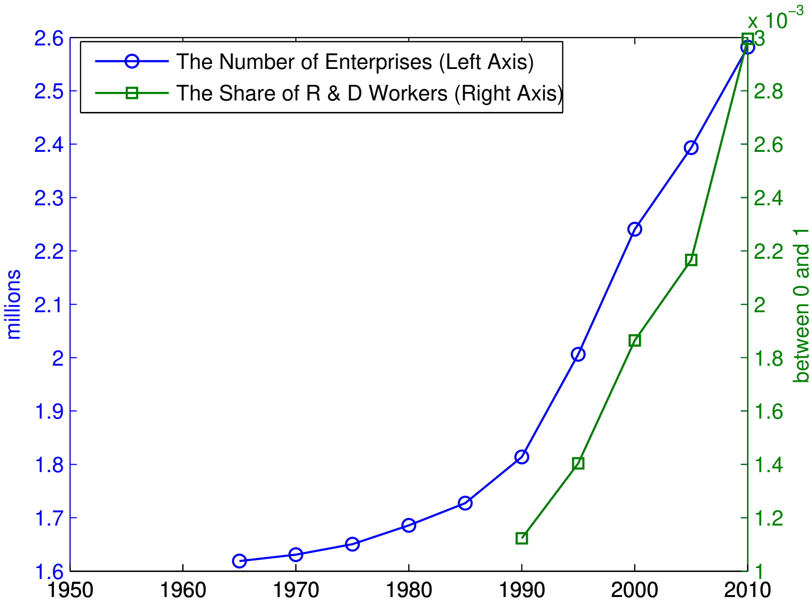

Figure 2: Enterprises and the R & D Personnel in Turkey

The data for the number of enterprises is from the Turkish Statistical Institute (2012, Table 15.1). The series is reconstructed from the numbers of entering and exiting enterprises for five-year intervals. The data for the R & D personnel is from the Turkish Statistical Institute (2013).

horizontal and vertical dimensions of technological progress.[15]

The model economy of this paper tries to understand the economic growth experience of Turkish economy to the present and to the future within the unified growth perspective that emphasizes *the continuity of the process of economic growth once it starts*. Figure 1 pictures the evolution of real GDP per capita in Turkey and its future path that would be attained under a constant rate of growth, and Figure 2 suggests that a second-generation Schumpeterian model such as that of Peretto and Valente (2011) can be used to shed light on the aggregate TFP dynamics in Turkey. This is not to mean that one should be overly optimistic about the long-run prospects of technological progress in Turkey. Models are just models, and nothing *in reality* guarantees that the engines of technological progress in Turkey will remain at work in the future. Models, however, are extremely useful if one wants to discipline the facts and to design counterfactual experiments rigorously. This paper, motivated by the data pictured in Figures 1 and 2, uses the theoretical framework of a second-generation Schumpeterian model in semi-reduced-form for such purposes.

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15. The model constructed by Peretto and Valente (2011) is also important for providing a rationale for a stabilizing level of population in the long run and in solving for the endogenously determined carrying capacity of the economy with respect to population.

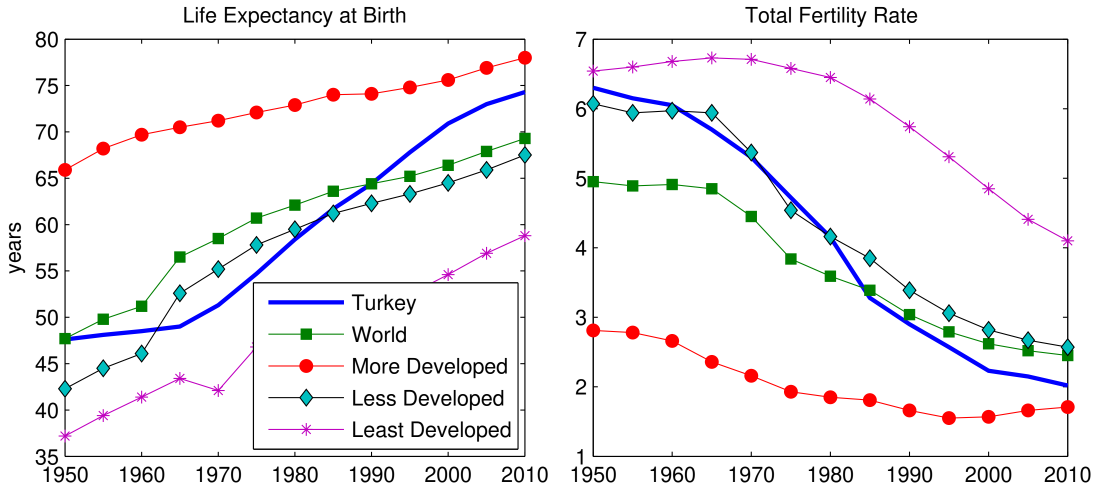

Figure 3: A Picture of the Demographic Transition across the World

The data is from the the United Nations (2010). Both life expectancy at birth and the total fertility rate represent the averages of the following five-year periods.

2.2. Population Aging in the World and in Turkey

One would make no mistake by calling the process of population aging *universal*. Figure 3 shows the recorded life expectancy at birth and total fertility rate for certain groups of economies, for the world, and for Turkey. The more developed countries in 1950 had substantially higher life expectancies and substantially lower fertility. There is, however, nothing unique about these records other than the fact that these are the countries that started modernizing earlier.[16]

The demographic transition of Turkey summarized in Figure 3 is remarkable. Compared with the averages of the less developed, least developed, and the world, the life expectancy and the total fertility rate for Turkey are the closest to those of more developed countries at the end of the sample. Despite this fast transformation, however, the aging of the population in Turkey is still at its very early steps. According to the United Nations (2010), the median age in Turkey was 19.7 in 1950 and 28.3 in 2010, and the medium variant projections indicate that it will reach its historical maximum of 47.0 in 2085.

The discussion of the *problem* of population aging requires the inspection of the

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16. To have a sense of the historical continuity here, note that the life expectancy at birth and the total fertility rate in England and Wales were respectively around 40 and 5.3 at the very beginning of the 19th century (Woods, 2000). On the diffusion of the demographic transition, the nonparametric evidence by Strulik and Vollmer (2010) indicate that, while there exists a club of low fertility that exhibits within-club convergence, the group of the countries with high fertility does not exhibit such a tendency. This would loosely suggest, from a purely empirical point of view, that having high levels of fertility is transitory because more countries with high fertility rates are expected to converge to the low-fertility club in the future.

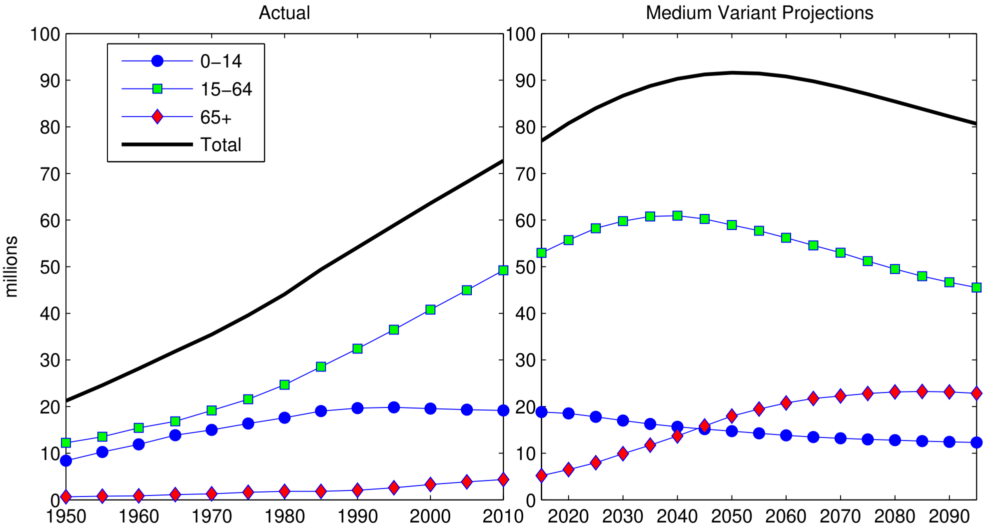

Figure 4: Population in Turkey: 1950-2095

The data for the five-year age groups is from the United Nations (2010). 0-14, 15-64, and 65-and-over populations are calculated accordingly.

working-age and the dependent populations. Figure 4 pictures the actual and the projected medium variant population levels for the dependent 0-14 and 65-and-over age groups and for the working-age 15-64 age group in Turkey. It is evident from this figure that Turkey has still around 25 years to benefit from its demographic dividend; the total working-age population is expected to decline after 2040. It is also evident that more than half of the total population in 2095 will be expected to remain in the working-age population. Figure 5, on the other hand, shows the actual and the projected medium variant dependency ratios for Turkey. These indicate expected increases in the total and the old dependency ratios after 2020s, and, even if the total dependency ratio is expected to remain lower than its pre-1970s levels, the expected increases show the upcoming threat of population aging in Turkey.

How sound such discussions of population aging are remains as a serious question basically because the dependency ratios do not take into account how mere numbers of people from different age groups have economic and social effects when these people live, work, and retire in a dynamic economy where fertility declines, technology progresses, and the structural transformation continues. In this regard, what this paper attempts to build is an economic approach to the question of population aging in Turkey even though the scope is limited with measures such as income and consumption per capita and no new "economic dependency" measure is explicitly defined.

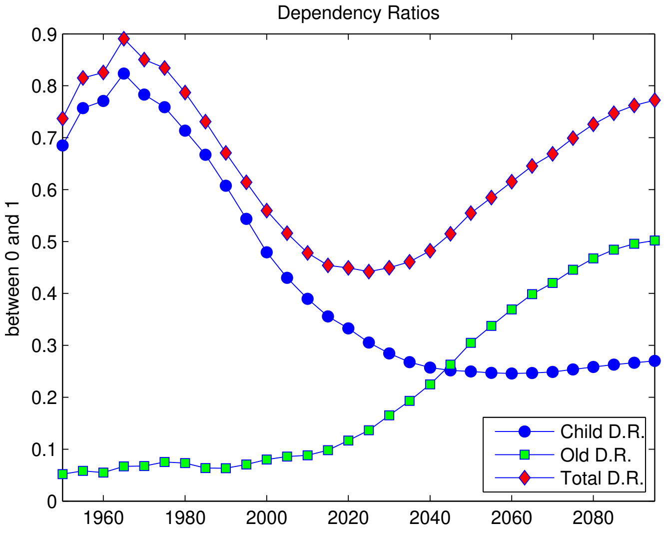

Figure 5: The Dependency Ratios in Turkey: 1950-2095

The dataset for the five-year age groups is from the United Nations (2010). 0-14, 15-64, and 65-and-over populations are calculated accordingly. The Child Dependency Ratio is the ratio of 0-14 population to 15-64 population, the Old Dependency Ratio is the ratio of 65-and-over population to 15-64 population, and, finally, the Total Dependency Ratio is the ratio of the sum of 0-14 and 65-and-over populations to 15-64 population.

3. The Model Economy

3.1. The Virtues and the Limitations of the Reduced-Form Approach

Studies that aim to analyze the effects of population aging in general equilibrium environments with endogenous technological progress, endogenous fertility, and the realistic demography of aging face the difficulty that we do not have *this* model (yet). The problem is most recently reiterated by Bruce and Turnovsky (2012) who develop a model with a realistic treatment of population aging but still without endogenous technological progress.[17]

The potentials are much more limited when technological progress is to be approached in the line of models that incorporate endogenous thresholds for the activation of various types of innovative activities—e.g., Desmet and Parente (2012) and Peretto and Valente (2011). A quantitative analysis of such models require data on the very early phases of economic development during which the economy stagnates with an almost zero rate of technological progress. Such a set of data for Turkey and the Ottoman Empire is not available.

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[17] The realistic demography of aging is meant to imply a demographic structure that goes beyond the standard structures of two or three overlapping generations.

These considerations motivate a semi-reduced-form version of a second-generation Schumpeterian growth model in the fashion of Peretto (1998) and Peretto and Valente (2011). Basically, four decisions agents would take in general equilibrium are handled in reduced-form, and four elements of the model—births per capita, the saving rate, the share of R & D workforce, and the share of Entry workforce—are assumed to be the functions of output per capita, i.e., the variable assumed to be carrying the information of at what stage of its development the economy is.

The major limitation of this reduced-form approach is that, since the model is set in semi-reduced-form with some components being similar to those of the corresponding general equilibrium setup of Peretto and Valente (2011), there is in fact an unknown mapping from the structural parameters of the model to the reduced-form functions. This means that the model economy constructed cannot be legitimately used to study the effects of parameter changes. The only exception is a preference parameter for fertility that does not show up explicitly in the general equilibrium solutions of the shares of R & D and Entry workforce in Peretto and Valente (2011). Here, it is assumed that, when this fertility parameter changes, it affects the shares of R & D and Entry workforce through its effect on output per capita.[18] See Laincz and Peretto (2006) for an explanation of the logic of such models of R & D and Entry.

3.2. A Brief Overview

The time in the model, denoted by t and starting at $t = 0$, is discrete and increases to infinity. The length of a period is 5 years for it implies a direct mapping from model into the population data of the United Nations (2010). The economy is closed to international trade and capital flows, and there does not exist government activity. The model also assumes away human capital accumulation and unemployment, and all working-age individuals are assumed to have a unit time endowment either spent to child rearing or supplied to the labor market inelastically.

The economy, in period t, produces a mass N_t of differentiated goods using physical capital and labor as tangible factors of production. This mass of goods is subject to change in time due to horizontal innovation (or Entry) and exit. There also exists an intangible factor X_{it} of production that represents the state-of-the-art level of knowledge associated with the production of good $i \in [0, N_t]$. X_{it} is subject to increase, for each i, as a result of vertical innovation (or R&D).

Population is disaggregated into three age groups: the 0-14 group of children, the 15-64 group of working-age adults, and the 65-and-over group of the old. The stock of physical capital changes in time depending on the levels of gross investment and depreciation. Specifically, an endogenous fraction of total production—the saving rate

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[18] Note, in advance, that this parameter does change only in one set of experiments.

or the investment share—is allocated as investment expenditure.

3.3. The Model

3.3.1. *Population*

Let $j \in \{\mathrm{c}, \mathrm{w}, \mathrm{o}\}$ index the three age groups such that c, w, and o respectively correspond to 0-14, 15-64, and 65-and-over populations. Denote by P_t^j the population of the age group j at the beginning of period t; the total population is thus equal to $P_t \equiv P_t^{\mathrm{c}} + P_t^{\mathrm{w}} + P_t^{\mathrm{o}}$. The dynamics of $\{P_t^j\}_{j\in\{\mathrm{c,w,o}\}}$ satisfy

$$\begin{aligned} P_{t+1}^{\mathrm{c}} - P_t^{\mathrm{c}} &= B_t - D_t^{\mathrm{i}} - R_t^{\mathrm{cw}} - D_t^{\mathrm{c}} + M_t^{\mathrm{c}} && (1)\\ P_{t+1}^{\mathrm{w}} - P_t^{\mathrm{w}} &= R_t^{\mathrm{cw}} - R_t^{\mathrm{wo}} - D_t^{\mathrm{w}} + M_t^{\mathrm{w}} && (2)\\ P_{t+1}^{\mathrm{o}} - P_t^{\mathrm{o}} &= R_t^{\mathrm{wo}} - D_t^{\mathrm{o}} + M_t^{\mathrm{o}} && (3) \end{aligned}$$

where B_t denotes the total number of live births, D_t^{i} denotes the total number of infant deaths, and $\{D_t^j\}_{j\in\{\mathrm{c,w,o}\}}$ and $\{M_t^j\}_{j\in\{\mathrm{c,w,o}\}}$ respectively denote the total number of deaths and the level of net migration for the age group j. Here, R_t^{cw} and R_t^{wo} represent the numbers of individuals whose age groups change from t to $t+1$: The former denotes the number of those moving from childhood to working-age, and the latter denotes the number of those moving from working- to old-age.[19]

To be explicit about R_t^{cw} and R_t^{wo} is necessary because not all individuals in 0-14 and 15-64 age groups move to the higher age groups in period t. Specifically, R_t^{cw} and R_t^{wo} in the population dataset of five-year age groups respectively correspond to the 15-19 and 65-69 populations in period $t+1$.

Let $b_t \equiv B_t/P_t$ denote births per capita. This measure of fertility is the key variable of interest in this paper and assumed to be endogenously changing with output per capita y_t. Specifically, we have

$$b_t \equiv b(y_{t-1}) \tag{4}$$

where $b(y_{t-1}) : \mathbb{R}_{++} \to \mathbb{R}_{++}$ is continuous, strictly decreasing and bounded from below such that

$$b^\star \equiv \lim_{y_{t-1}\to\infty} b(y_{t-1}) > 0 \tag{5}$$

The fertility behavior characterized by (4) and (5) deserves some comments: The

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[19] Notice that the side-by-side summation of equations (1) to (3) yields the dynamics of total population as in

$$\sum_j P_{t+1}^j - \sum_j P_t^j = B_t - D_t^{\mathrm{i}} - \sum_j D_t^j + \sum_j M_t^j$$

continuity of $b(\bullet)$ is for simplicity only, and the dependence to lagged y_t is for computational ease. That b_t is strictly decreasing with y_{t-1} is perhaps the easiest way to "model" the fertility decline in a growing economy where there exists a quality-quantity trade-off in fertility choice.[20]

Mortality and migration patterns are exogenous, and one needs to be careful about which per capita measures of mortality and migration are invariant to the changes in fertility. Define

$$r_t^{\mathrm{cw}} \equiv \frac{R_t^{\mathrm{cw}}}{P_t^{\mathrm{c}}}, r_t^{\mathrm{wo}} \equiv \frac{R_t^{\mathrm{wo}}}{P_t^{\mathrm{w}}}, p_t^{\mathrm{c}} \equiv \frac{P_t^{\mathrm{c}}}{P_t}, p_t^{\mathrm{cw}} \equiv \frac{P_t^{\mathrm{c}}}{P_t^{\mathrm{w}}}, p_t^{\mathrm{wo}} \equiv \frac{P_t^{\mathrm{w}}}{P_t^{\mathrm{o}}}, d_t^{\mathrm{i}} \equiv \frac{D_t^{\mathrm{i}}}{B_t}$$

and

$$d_t^j \equiv \frac{D_t^j}{P_t^j}, m_t^j \equiv \frac{M_t^j}{P_t^j} \quad \forall\, j \in \{\mathrm{c}, \mathrm{w}, \mathrm{o}\}$$

Equations (1), (2) and (3) can now respectively be written as

$$P_{t+1}^{\mathrm{c}} - P_t^{\mathrm{c}} = \left[\frac{\left(1-d_t^{\mathrm{i}}\right) b_t}{p_t^{\mathrm{c}}} - r_t^{\mathrm{cw}} - d_t^{\mathrm{c}} + m_t^{\mathrm{c}}\right] P_t^{\mathrm{c}} \tag{6}$$

$$P_{t+1}^{\mathrm{w}} - P_t^{\mathrm{w}} = \left(r_t^{\mathrm{cw}} p_t^{\mathrm{cw}} - r_t^{\mathrm{wo}} - d_t^{\mathrm{w}} + m_t^{\mathrm{w}}\right) P_t^{\mathrm{w}} \tag{7}$$

$$P_{t+1}^{\mathrm{o}} - P_t^{\mathrm{o}} = \left(r_t^{\mathrm{wo}} p_t^{\mathrm{wo}} - d_t^{\mathrm{o}} + m_t^{\mathrm{o}}\right) P_t^{\mathrm{o}} \tag{8}$$

and, under the assumption that $\{r_t^{\mathrm{cw}}, r_t^{\mathrm{wo}}, d_t^{\mathrm{i}}, d_t^{\mathrm{c}}, m_t^{\mathrm{c}}, d_t^{\mathrm{w}}, m_t^{\mathrm{w}}, d_t^{\mathrm{o}}, m_t^{\mathrm{o}}\}$ remains same when b_t changes exogenously, (6)-(8) allow one to keep track of changes in each population age group *given* mortality and migration per capita. In other words, when there is a shift in b_t, the same *fraction* of all infants die, the same *fractions* of 10-14 and of 60-64 population move to the higher age groups, and the same *fraction* of individuals die and migrate, and the model isolates the effects of the changes in fertility from other demographic determinants.[21]

3.3.2. Production

Let there exist an aggregate consumption index Y_t of the differentiated goods as in

$$Y_t \equiv \left(\int_0^{N_t} Y_{it}^{\frac{\eta-1}{\eta}} \mathrm{d}i\right)^{\frac{\eta}{\eta-1}} \tag{9}$$

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20. As argued by Jones et al. (2011), there is no behavioral theory that robustly explains the negative income-fertility correlation.
21. Section 4 explains how the data is used to obtain these invariant ratios.

where $\eta > 1$ is the elasticity of substitution, N_t is the mass of differentiated goods, and Y_{it} is the flow of good i in period t.

Suppose that the differentiated good $i \in [0, N_t]$ is produced with a Cobb-Douglas technology of the form

$$Y_{it} = X_{it} k_{it}^{\alpha} \ell_{Yit}^{1-\alpha}$$

with $\alpha \in (0,1)$, where Y_{it} denotes the level of output, X_{it} represents the measure of productivity, k_{it} is the stock of physical capital employed, and ℓ_{Yit} is the flow of the homogeneous labor input.

In a symmetric equilibrium of this model economy, the local monopoly i producing the differentiated good i employs $k_{it} = k_t$ and $\ell_{Yit} = \ell_{Yt}$ as capital and labor. Defining the average productivity as in

$$X_t \equiv \frac{1}{N_t} \int_0^{N_t} X_{it} \mathrm{d}i$$

and assuming that all local monopolies attain the average productivity in the initial period, the symmetric level of production in period t is equal to $X_t k_t^{\alpha} \ell_{Yt}^{1-\alpha}$. Thus, the total production, by (9), is equal to

$$Y_t = N_t^{\frac{\eta}{\eta-1}} X_t k_t^{\alpha} \ell_{Yt}^{1-\alpha} \tag{10}$$

Define now the aggregate levels of k_t and ℓ_{Yt} respectively as $K_t \equiv N_t k_t$ and $L_{Yt} \equiv N_t \ell_{Yt}$. (10) then implies the familiar aggregate production function

$$Y_t = N_t^{\sigma} X_t K_t^{\alpha} L_{Yt}^{1-\alpha} \tag{11}$$

where $\sigma \equiv (\eta - 1)^{-1} > 0$ represents the positive externality associated with the increasing variety of goods.

3.3.3. Capital Accumulation

Suppose that the stock of physical capital changes in time according to the standard law of motion of the form

$$K_{t+1} - K_t = s_t Y_t - \delta K_t \tag{12}$$

where $s_t \in (0,1)$ is the fraction of total production allocated as investment and $\delta \in (0,1)$ is the depreciation rate.

The investment share s_t is endogenous and changing with y_{t-1} via

$$s_t \equiv s(y_{t-1}) \tag{13}$$

where $s(y_{t-1}) : \mathbb{R}_{++} \to (0,1)$ is continuous, strictly increasing and bounded from above such that

$$s^\star \equiv \lim_{y_{t-1}\to\infty} s(y_{t-1}) \in (0,1) \tag{14}$$

The motivation behind (13) and (14) is empirical: As recently reiterated by Strulik (2012), the saving rates are not only higher in richer countries and for richer households in a country but also have a clear increasing trend *within* a country in the long run. In Turkey, according to the PENN World Tables of Heston et al. (2012), the investment share in GDP was less than 10% in 1950s and is around 20% in the first decade of the 21st century.[22]

3.3.4. *Technological Progress*

Consider the aggregate representation of the production in (11). The relevant measure of TFP given this aggregate is

$$Z_t \equiv N_t^\sigma X_t$$

Technological progress has thus two dimensions: the average productivity X_t along the vertical dimension of purposeful R & D investments and the number N_t of product varieties along the horizontal dimension of entry. What follows next is a discussion of how X_t and N_t change in time.

R & D. Suppose that each local monopoly $i \in [0, N_t]$ purposefully invests in R & D and realizes an incremental increase in its productivity X_{it} via the research technology of the form

$$X_{it+1} - X_{it} = \gamma \ell_{Xit} X_t \tag{15}$$

with $\gamma > 0$, where $\ell_{Xit} > 0$ is the flow of labor input allocated to R & D by firm i. Under symmetry across i, we have $\ell_{Xit} = \ell_{Xt}$, and (15) implies

$$X_{t+1} - X_t = \gamma \ell_{Xt} X_t \tag{16}$$

The task here is to specify how ℓ_{Xt} is determined in reduced-form. Define firstly the total R & D workforce in the economy as $L_{Xt} \equiv N_t \ell_{Xt}$. Since every working-age

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[22] Strulik (2012) uses this historical regularity as a motivating point for an extension of the neoclassical growth model with the time-preference rates endogenously changing with wealth.

individual has a unit time endowment supplied inelastically, the labor share of R & D satisfies

$$\hat{\ell}_{Xt} \equiv \frac{L_{Xt}}{P^{\mathrm{w}}_t}$$

and it is assumed that $\hat{\ell}_{Xt}$ changes endogenously with y_{t-1} as in the cases of b_t and s_t. Specifically, we have

$$\hat{\ell}_{Xt} \equiv \hat{\ell}_X(y_{t-1}) \tag{17}$$

where $\hat{\ell}_X(y_{t-1}) : \mathbb{R}_{++} \to (0,1)$ is continuous, strictly increasing and bounded from above such that

$$\hat{\ell}^{\star}_X \equiv \lim_{y_{t-1}\to\infty} \hat{\ell}_X(y_{t-1}) \in (0,1) \tag{18}$$

Entry and Exit. The law of motion for N_t is specified as in

$$N_{t+1} - N_t = \phi L_{Nt} - e_t N_t \tag{19}$$

where $\phi > 0$ is a parameter that represents the unit productivity of labor in research towards entry, L_{Nt} is the flow of labor allocated into this research activity, and $e_t \in (0,1)$ is the common exit rate that is exogenous. What motivates a time-varying exit rate is the data that shows a sharp increase in the percentage of exiting firms in Turkey after 1990s.

The share ℓ_{Nt} of Entry workforce, as in the case of $\hat{\ell}_{Xt}$, is an important determinant of technological progress and defined as in

$$\ell_{Nt} \equiv \frac{L_{Nt}}{P^{\mathrm{w}}_t}$$

In reduced-form, it is assumed that ℓ_{Nt} changes endogenously with y_{t-1} as in the cases of b_t, s_t, and $\hat{\ell}_{Xt}$:

$$\ell_{Nt} \equiv \ell_N(y_{t-1}) \tag{20}$$

Here, $\ell_N(y_{t-1}) : \mathbb{R}_{++} \to (0,1)$ is a continuous and strictly increasing function that is bounded from above such that

$$\ell^{\star}_N \equiv \lim_{y_{t-1}\to\infty} \ell_N(y_{t-1}) \in (0,1) \tag{21}$$

3.3.5. The Cost of Reproduction and the Labor Market

We can now close the model by imposing the resource constraint with respect to labor.

On the demand side, we have the total Entry workforce L_{Nt}, the total R & D workforce L_{Xt}, and the total production workforce L_{Yt}.

On the supply side, it is assumed that b_t births per capita where 15-64 population is equal to P^{w}_t cost $\psi b_t P^{\mathrm{w}}_t$ units of labor. Here, $\psi > 0$ is a fixed parameter that represents the "unit" time cost of reproduction, and this is the simplest way to model the time cost where the relevant fertility measure is b_t.[23] With $\psi b_t P^{\mathrm{w}}_t$ units of labor being allocated to child rearing, the total supply of labor is equal to $P^{\mathrm{w}}_t(1-\psi b_t)$. The resource constraint thus solves the only undetermined variable of the model, L_{Yt}, as in

$$L_{Yt} = P^{\mathrm{w}}_t(1-\psi b_t) - L_{Xt} - L_{Nt} \tag{22}$$

4. Data and the Benchmark Calibration[24]

This and the following section summarize the results of the benchmark calibration and the counterfactual experiments. For the entire analysis, the horizon of the model starts from the year 1950 and extends to the period 2095-2100 at which the 2010 Revision of World Population Prospects by the United Nations (2010) ends.

4.1. Data Sources

There are four main sources for the data used in this paper. These are the World Population Prospects of the United Nations (2010), the Statistical Indicators by the Turkish Statistical Institute (2012), the PENN World Tables 7.1 of Heston et al. (2012), and the data by the Turkish Statistical Institute (2013) on the R & D personnel by occupation and sector of employment.

The United Nations (2010) provide data and projections (*i*) on population for five-year age groups from 0-4 to 100-and-over, (*ii*) on births, deaths, and net migration, and (*iii*) on other demographic indicators such as the total fertility rate and the median age, all for the period 1950-2100. The quantitative work of this paper utilize (*i*) and (*ii*) with medium variant projections. On the annual numbers of newly established and liquidated enterprises, the data used is from the Turkish Statistical Institute (2012). This covers the period of 1965-2011, and the original source of the data is *the Union of*

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[23] In models that feature a time cost of reproduction, the fertility variable is in general taken to be the number of children per adult, and the time cost is specified at the individual level.

[24] The careful reader may be urged to raise, at this point, the question of what the steady-state of this economy does look like. This paper does not study the steady-state basically because the scope is limited with the effects of fertility changes in the near future. The models of this class in general attain well-behaved and unique steady-states that exhibit saddle-path stability. With endogenous population growth, the important question is by which mechanism the level of population stabilizes in finite time. Note that, since mortality and migration are exogenous and fertility is treated in reduced-form, a steady-state could easily be constructed. This, however, would not change the main results of the paper.

Chambers and Commodity Exchanges of Turkey. Finally, the PENN World Tables 7.1 of Heston et al. (2012) provide, for the years 1950-2010, the Purchasing Power Parity converted GDP per capita in 2005 dollars and the share of investment expenditures in the GDP.

4.2. Mortality, Migration, and the Working-Age Population

Recall that (*i*) per capita measures of mortality and migration and (*ii*) the *fractions* of individuals moving from 10-14 to 15-19 and from 60-64 to 65-69 age groups are to be calculated since these measures are not readily available from the data.

First, r_t^{cw} and r_t^{wo} are calculated from the data as in

$$r_t^{\mathrm{cw}} = \frac{\text{No. of individuals aged 15-19 in } t+1}{\text{No. of individuals aged 10-14 in } t}$$

$$r_t^{\mathrm{wo}} = \frac{\text{No. of individuals aged 65-69 in } t+1}{\text{No. of individuals aged 60-64 in } t}$$

where the need to look at one period ahead arises because the numbers of deaths and migrants for each five-year age group are not observed—e.g., the total number of individuals moving from 10-14 to 15-19 age group *in* period t should be among the surviving and the non-migrating of the 10-14 age group.

Next, since the population sums of the age groups c, w, and o and b_t and d_t^{i} are known, equations (6) to (8) can respectively be used to solve for

$$-d_t^{\mathrm{c}} + m_t^{\mathrm{c}} \qquad -d_t^{\mathrm{w}} + m_t^{\mathrm{w}} \qquad -d_t^{\mathrm{o}} + m_t^{\mathrm{o}}$$

Since both death and migration works in the same way in determining the working-age population, knowing the *per capita* measure $\left(-d_t^j + m_t^j\right)$ for the age group $j \in \{\mathrm{c,w,o}\}$ is all what the quantitative analyses of this paper need.

4.3. The Calibration Strategy

4.3.1. *The First Step: Calibrating γ, ϕ, ψ and K_0*

In this first step, three structural parameters of the model, i.e., γ, ϕ and ψ, and the initial value of the stock of physical capital, i.e., K_0, are calibrated to match the evolution of output per capita y_t from 1955 to 2010. The algorithm used, by solving the model for each iterate of $(\gamma, \phi, \psi, K_0)$, minimizes a quadratic form of scaled deviations—between model-generated observations that depend on $(\gamma, \phi, \psi, K_0)$ and the observed data—defined as in

$$Q(\pi) \equiv \sum_{t=1}^{12} \left[\frac{y_t^{\text{data}} - y_t(\pi)}{0.5(y_t^{\text{data}} + y_t(\pi))} \right]^2$$

where $\pi \equiv (\gamma, \phi, \psi, K_0)$.

The capital elasticity α of output in (11) is set to 0.3 as in Çiçek and Elgin (2011), and the elasticity η of substitution in (9) is set to 2.5 as in Connolly and Peretto (2003). The five-year depreciation rate δ is calculated via

$$\delta = 1 - (1 - \delta_{\text{annual}})^5$$

where δ_{annual} estimated for Turkey by Çiçek and Elgin (2011) is 0.047. The implied value of δ is equal to 0.2139. The initial values of P_t^j for $j \in \{\text{c,w,o}\}$ and of N_t is set from the data in millions, and X_0 is normalized so that $Z_0 = 1$.

For this calibration to work, the model must be fed by the data sequences of b_t, s_t, $\hat{\ell}_{Xt}$ and ℓ_{Nt} that are specified in the second step as functions of y_{t-1} and all the other exogenous sequences of the demographic variables.

For b_t, the data for B_t and P_t from the United Nations (2010), and, for s_t, the investment share data in the PENN World Tables 7.1 of Heston et al. (2012) are used. The latter is reconstructed as the five-year averages to obtain some smoothness.

For $\hat{\ell}_{Xt}$, a limiting value of $\hat{\ell}_X^\star = 0.0077$ is set. This is the corresponding average value of 2005-2010 for the United Kingdom according to *the World Development Indicators*.[25] Then, using the Turkish Statistical Institute (2013) data for the period 1990-2010, a logistic fit for 1950-2095 is calculated using the `imfil` package written by Kelley (2011).[26]

A similar approach is followed to construct ℓ_{Nt} where the dynamics of firm entry and exit in the data from the Turkish Statistical Institute (2012) are informative. First, since the exit rate e_t shows a sharp increase in 1990s and is bounded above, a logistic function of t with a steady-state exit rate of 5.5% is fitted.[27] Then, $\phi\ell_{Nt}$ in the data is constructed using the data on N_t, the fitted series e_t, and the working-age population P_t^{w}. After this, an arbitrary benchmark value of 0.007 is imposed for $\phi\ell_{Nt}$, and a logistic fit as a function of t is obtained.[28]

With all the inputs being fed into the model in the ways discussed above, the

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[25] The reason of why, say, the corresponding value for the United States is not used is the lack of headcount data in R & D.

[26] `imfil` package executes an exhaustive search over the parameter space to achieve global minima, and the search is responsive to hidden constraints originating from the construction of the model. In this paper, `imfil` package is used even though the model does not have any hidden constraints.

[27] This is close to the exit rate in the United States in tranquil times of business cycles; see Tutino and Cheremukhin (2012, Fig. 2).

[28] Note that, since the calibration algorithm chooses ϕ, the arbitrariness of 0.007 does not affect the quantitative results significantly.

Table 1: The Benchmark Calibration (The First Step Results)

Parameter / Initial Value	Symbol	Value	Comment / Source
Capital Share	α	0.300	Çiçek and Elgin (2011)
Elasticity of Substitution	η	2.500	Connolly and Peretto (2003)
Depreciation Rate	δ	0.214	Calculated from the annual depr.
R & D Technology	γ	0.313	Calibrated (1st Step)
Entry Technology	ϕ	0.039	Calibrated (1st Step)
Cost of Reproduction	ψ	0.718	Calibrated (1st Step)
Physical Capital	K_0	0.111	Calibrated (1st Step)
Enterprises	N_0	1.582	Data
Productivity	X_0	0.736	Implying $Z_0 = 1$ given N_0 and η
0-14 population	P_0^c	8.377	Data
15-64 population	P_0^w	12.227	Data
65-and-over population	P_0^o	0.634	Data

Table 2: The Fitted Functions for b_t, s_t, $\hat{\ell}_{Xt}$ and ℓ_{Nt}

Variable	Function
Births Per Capita (b_t)	$b(y_{t-1}) = 0.0504 + \frac{0.5679}{1+\exp[(5.2727)y_{t-1}]}$
The Saving Rate (s_t)	$s(y_{t-1}) = \frac{0.3524}{1+\exp[(-6.174)y_{t-1}]} - 0.1403$
The Share of R & D Workforce ($\hat{\ell}_{Xt}$)	$\hat{\ell}_X(y_{t-1}) = 0.001 + \frac{0.0077-0.001}{1+\exp[(-11.4872)(y_{t-1}-0.5905)]}$
The Share of Entry Workforce (ℓ_{Nt})	$\ell_N(y_{t-1}) = 0.0148 + \frac{0.0857-0.0148}{1+\exp[(-19.3905)(y_{t-1}-0.38728)]}$

algorithm that chooses $\pi \equiv (\gamma, \phi, \psi, K_0)$, in essence, uses the production function to match its inputs with its output. γ governs the dynamics of X_t, ϕ of N_t, and ψ of L_{Yt}. By choosing K_0 and, then, adjusting the scaling factor of y_t accordingly, the algorithm also chooses the capital-output ratio in the initial period. Table 1 summarizes the results.

4.3.2. The Second Step: Fitting the Reduced-Forms for b_t, s_t, $\hat{\ell}_{Xt}$ and ℓ_{Nt}

The first step of the calibration strategy returns the unknown model inputs given the data on b_t, s_t, $\hat{\ell}_{Xt}$, ℓ_{Nt} and on other population measures. Since only b_t is endogenous among the demographic variables, obtaining reduced-form functions for b_t, s_t, $\hat{\ell}_{Xt}$ and ℓ_{Nt} is necessary and sufficient to complete the task of calibration. In this second step, the functions in equations (4), (13), (17) and (20)—respectively for b_t, s_t, $\hat{\ell}_{Xt}$

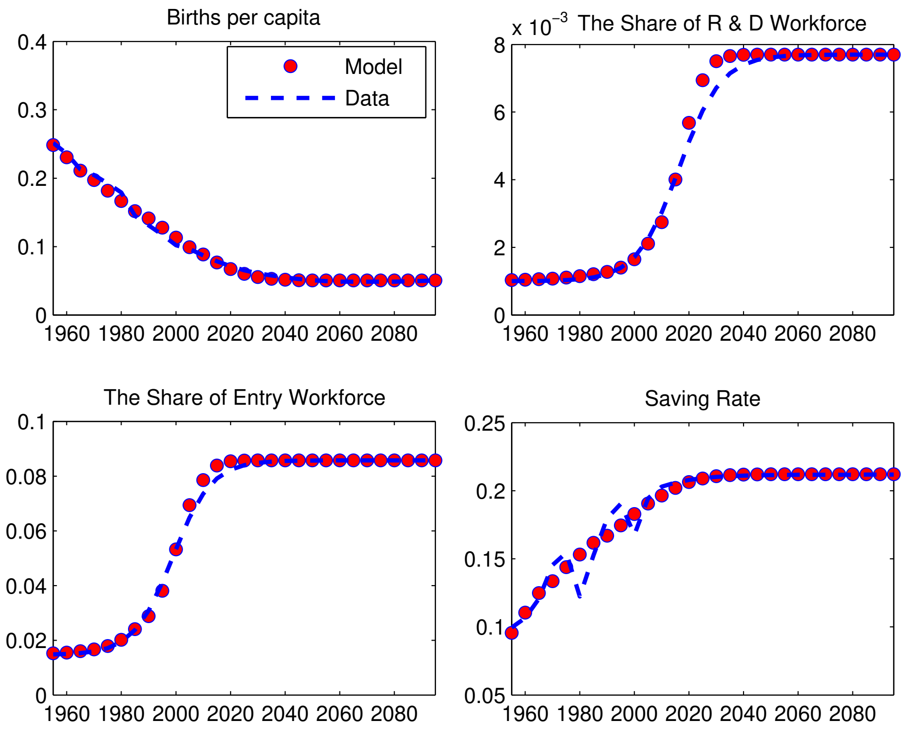

Figure 6: Model vs. Data: Fertility, Saving, and Technological Progress

and ℓ_{Nt}—are parameterized and fitted using the data for b_t, s_t, $\hat{\ell}_{Xt}$ and ℓ_{Nt} described above and the sequence of y_{t-1} obtained in the first step.

It turns out that, for all functions to be parameterized and fitted, a type of the generalized logistic function is the most appropriate alternative.[29] Table 2 presents these fitted logistic forms.

For future reference, the parameter of interest here is the numerator of the fraction in $b(y_{t-1})$. This parameter, in a complete model of economic demography, would be taken to represent the adults' preference for higher fertility and is equal to 0.5679 in the benchmark calibration.[30]

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[29] Since y_t grows in time and since $\hat{\ell}_{Xt}$ and ℓ_{Nt} are already described as logistic functions of t, this is not surprising for these two variables.

[30] What motivates this interpretation is the partial equilibrium solution to fertility in the model of Peretto and Valente (2011, Eq. (19)). This solution reads, *in the authors' notation*,

$$b(t) = \frac{\mu}{\frac{\phi}{y(t)} - h(t)}$$

where $\mu > 0$ is the parameter of fertility preference, $\phi > 0$ is a parameter representing the unit time cost of reproduction as in this paper, $y(t)$ is the consumption expenditure per capita and $h(t)$ is the shadow value of humanity that governs the optimal family size in the dynamic program of the representative dynasty.

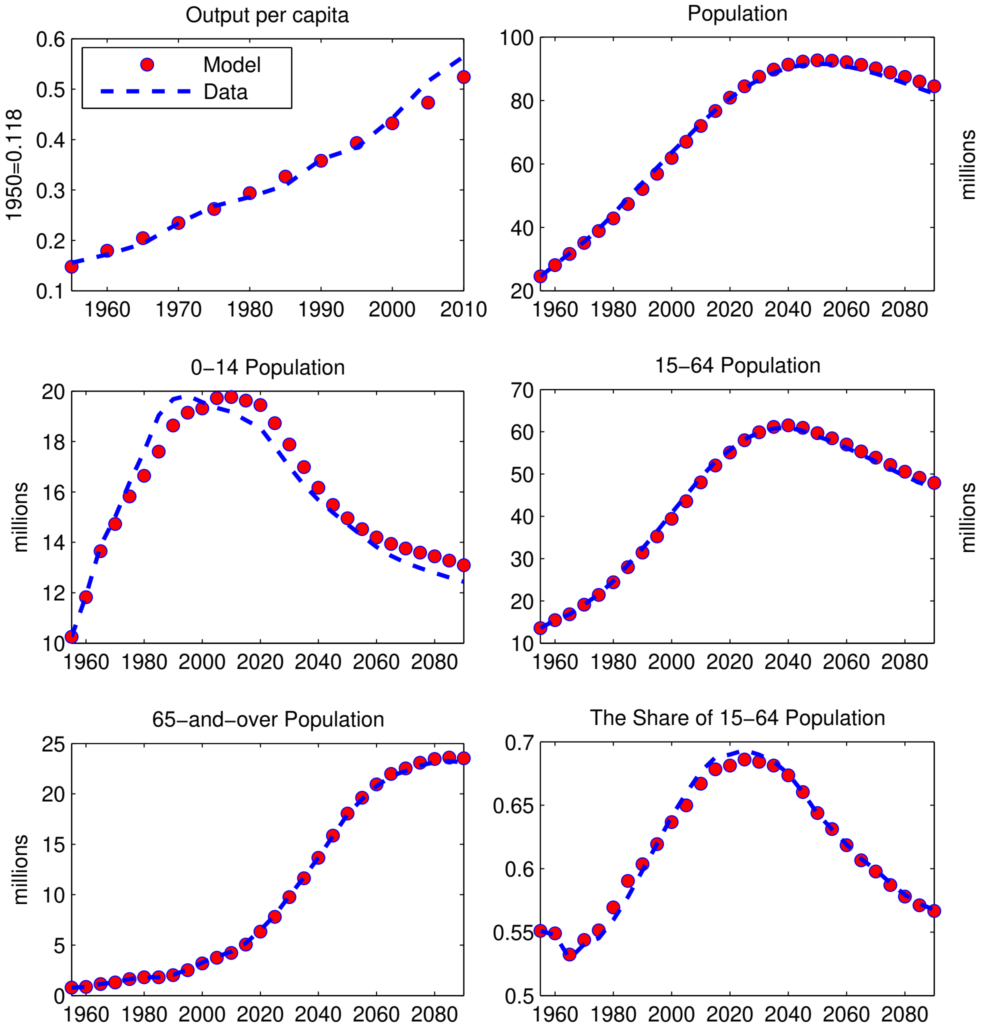

Figure 7: Model vs. Data: Output per capita and Population

4.4. The Benchmark Path of Economic Growth

The goodness-of-fit of the benchmark calibration is pictured in Figures 6 and 7. Overall, the model performs well in explaining the dynamics of fertility, the populations of different age groups, and output per capita. Since small deviations in births per capita naturally translate into large differences in levels, the relatively poorer performance of the model in matching b_t results in a relatively poorer performance in matching the 0-14 population. The effects on 15-64 and 65-and-over populations, on the other hand, remain very minor.

Of particular interest here is the future of economic growth in Turkey. Three different technological progress scenarios for the 21st century are considered:

- (ITP) The first technological progress scenario is the one the benchmark cali-

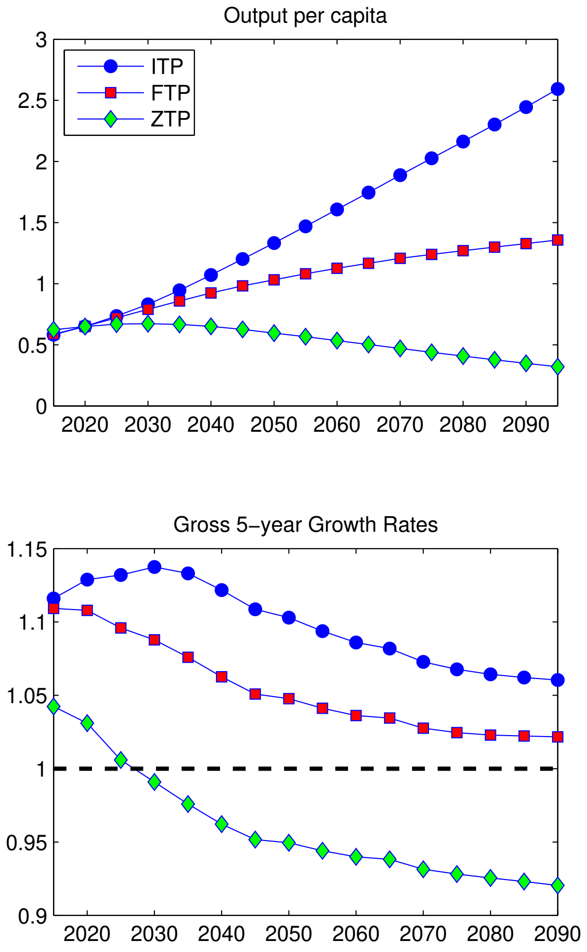

Figure 8: Economic Growth under Different Technological Progress Scenarios

bration builds upon. In this scenario, both ℓ_{Nt} and $\hat{\ell}_{Xt}$ are increasing functions of y_{t-1}. Due to the lack of a better choice, this technological progress scenario is labeled with ITP for Increasing rates of Technological Progress.

- (FTP) In the second technological progress scenario, both ℓ_{Nt} and $\hat{\ell}_{Xt}$ remain at their 2010 levels so that the period after 2015 represents Turkey's maximum potential for technological progress. This scenario is labeled with FTP for Fixed rates of Technological Progress.[31]
- (ZTP) The last scenario for ℓ_{Nt} and $\hat{\ell}_{Xt}$ considers the extreme situation of no technological progress beyond 2015. Specifically, ℓ_{Nt} and $\hat{\ell}_{Xt}$ are assumed to be equal to zero for 2015 and beyond. This third scenario is labeled with ZTP for Zero rates of Technological Progress.

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[31] Strictly speaking, since the exit rate e_t still increases, the growth rate of N_t under this scenario is not necessarily fixed.

Figure 8 pictures the resulting dynamics of the level of output per capita and its gross 5-year growth rates under these three scenarios.

It is evident from this figure that technological progress will be the major source of economic growth in Turkey in the upcoming decades. Under the third scenario with no technological progress, the gross 5-year growth rate sharply decreases into the zone of economic decline. On the other hand, the decline in the growth rate is common under all three scenarios. Technological progress in Turkey—even with increasing levels of ℓ_{Nt} and $\hat{\ell}_{Xt}$—is not fast enough to compensate for the effects of the decreases in the share of the working-age population.

Regarding the magnitudes of these growth slowdowns, the gross 5-year growth rate remains higher than 1.0604 at its lowest (in the year 2090) under the ITP scenario, and this corresponds to an annual growth rate of 1.18%. These gross 5-year and percentage annual rates for the FTP scenario are, respectively, 1.0216 and 0.43% per annum. Not surprisingly, if the technological transformation in Turkey stops where it is already, the future of economic growth would be remarkably *darker*.

5. The Effects of Fertility Changes: Two Experiments

We are now ready to see the effects of exogenous upward shifts in the fertility level and the fertility preference. Of interest are two counterfactual experiments:

1. The first experiment studies the effects of an exogenous upward jump of b_t, occurring in 2015, to its 1995 level where the corresponding (average) TFR was around 2.90. This jump is assumed to be *permanent* so that b_t remains fixed at its 1995 level until the end of the 21st century.

2. The second experiment, on the other hand, studies the effects of an exogenous permanent increase in the *preference* for higher fertility, again occurring in 2015, such that b_t jumps to its 1995 level in 2015, but, then, is allowed to vary with y_{t-1} as in the benchmark scenario. More specifically, the fertility preference parameter of 0.5679, the one that is emphasized above, permanently shifts to 1.1287 by a factor of 1.9875.

Both experiments are implemented under the three technological progress scenarios introduced above, and the Figures 9 and 10 respectively show the effects of Experiments 1 and 2 on

- births per capita,
- the dependent population,
- the share of the working-age population, and

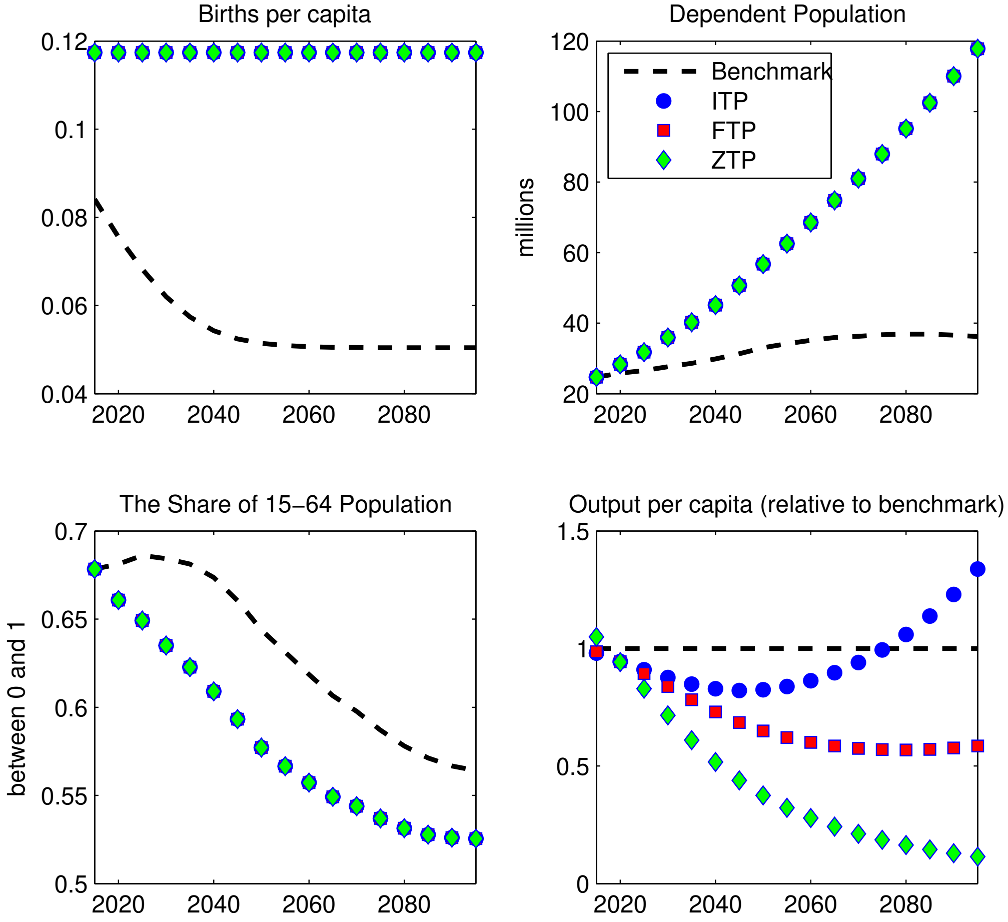

Figure 9: Effects of a Permanent Upward Shift in the Fertility Level

The direct shift in b_t is to its 1995 level. ITP, FTP, and ZTP are respectively for the scenarios of Increasing, Fixed, and Zero rates of Technological Progress. Output per capita is drawn relative to its benchmark.

- output per capita.[32]

From Figure 9 that shows the results of Experiment 1, it is clearly observed that the prime determinant of the dependent population and the share of the working-age individuals is the permanently higher *level* of births per capita.

Since a *constant* flow of babies join the 0-14 age group in every period, the share of the working-age population exhibits a very sharp decrease under all technological progress scenarios. Besides, after 2035-2040—when the benchmark share of the working-age population achieves a maximum—there remains a difference of around 10% between the benchmark and the experimented levels that persists until the end of the century. This is important in showing that a permanent upward shift in births

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[32] Note that the effects on consumption per capita are very close to the effects on output per capita.

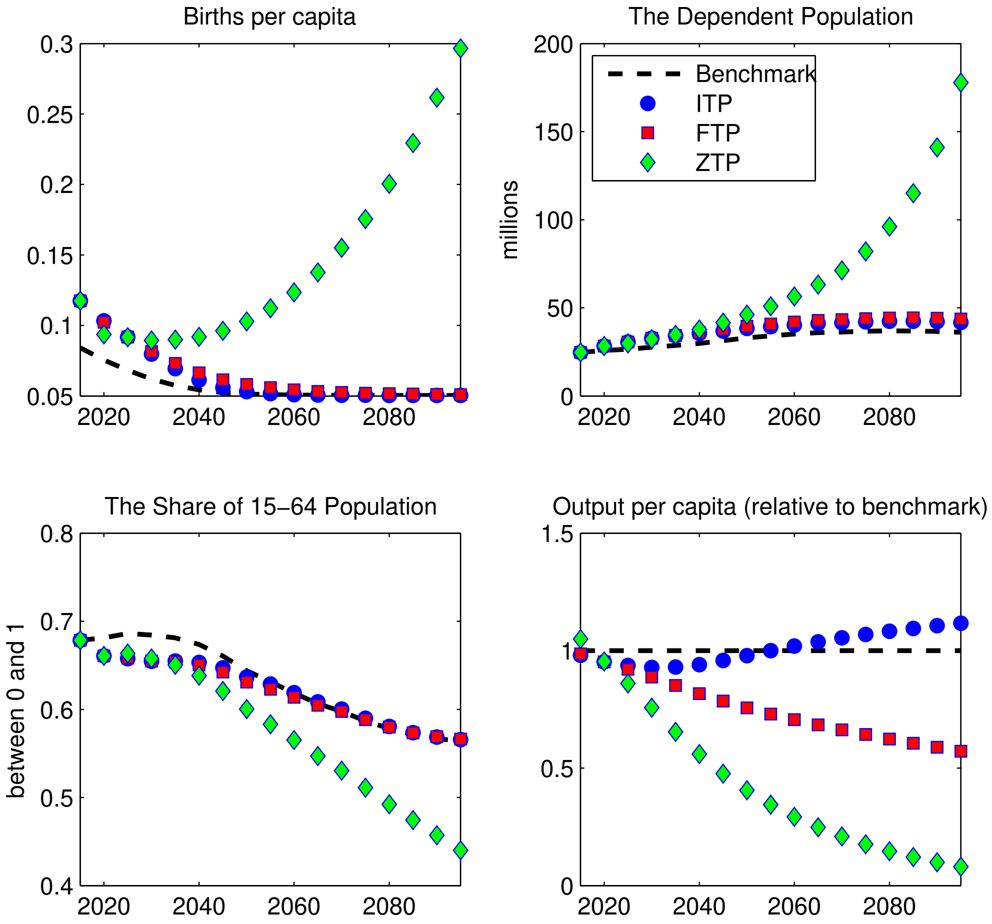

Figure 10: Effects of a Permanent Upward Shift in the Fertility Preference

The shift in b_t is to its 1995 level but occurs because the preference parameter for higher fertility shifts permanently. ITP, FTP, and ZTP are respectively for the scenarios of Increasing, Fixed, and Zero rates of Technological Progress. Output per capita is drawn relative to its benchmark.

per capita cannot solve the problem of increasing (total) dependency ratio if migration and mortality patterns remain as projected by the United Nations (2010).

Not surprisingly, the dependent population in Experiment 1 shows a fast and steady increase and approaches to the tremendous level of 120 million at the end of the century. This, again, is true for all technological progress scenarios and would raise, *in curious minds*, the question of whether the carrying capacity of Turkey for dependents is below or above this number.

The technological progress scenarios, on the other hand, do matter for the evolution of output per capita. The important result is that, even under the ITP scenario, a permanent shift in b_t results in a gradual but deep decrease relative to the benchmark growth path. Specifically, output per capita under the ITP scenario reaches its benchmark growth path as late as 2075-2080 while the acceleration of growth starts after 2050. Under the FTP scenario, on the other hand, output per capita persistently remains lower than its benchmark growth path while the decline itself decelerates at around 2060—leaving output per capita 45% lower than its benchmark. These figures are, of course, considerably worse under the ZTP scenario where the economy invests neither into R & D nor into Entry.

As Figure 10 shows, the situation changes remarkably under Experiment 2 which studies the permanent upward shift in fertility preference. In this experiment, since fertility keeps responding to output per capita, the increase in the dependent population and the decrease in the share of the working-age population remain *relatively* modest under the scenarios ITP and FTP. Even though the dependent population remains lower than 50 million under these two scenarios, however, the persisting differences from the benchmark remain within 5 to 10 million dependents. It is true that the share of the working-age population eventually catches up with its benchmark, but this happens as late as 2060. Besides, once again, the evolution of the working-age population under the ITP and FTP scenarios shows that a permanent deviation in the preference for higher fertility is not the solution to the increasing dependency in the long run.

The effects on output per capita also deserve some comments. Since fertility quickly decreases after its shift, the ITP scenario results in a modest decrease and a relatively quick recovery; the largest deviation is around -10% and the catching up with the benchmark occurs at around 2055. The FTP scenario however results in a discomforting deviation which would be around -45% at the end of the century.

Overall, then, neither of the two experiments indicates a benefit resulting from higher fertility. In contrast, both experiments show that higher fertility would not serve as a cure for the expected decline of the working-age population—if it does not make the situation worse as in the case of 120 million dependents.

6. Discussion

The results presented in the last two sections, respectively, show that (*i*) technological progress will be the major source of economic growth in Turkey throughout this century and (*ii*) the return to demographic growth with higher fertility rates would not only make the prospects of output per capita worse for many decades but also result in higher dependency measures in the future.

This section provides a brief discussion of these results with special emphases on three issues: First, since the ITP scenario indicates that output per capita would be higher in both experiments after its decline and its catch-up, the issue of intergenerational conflict deserves some space in this paper. Second, some remarks on the congestion effects of increasing dependency are presented for those who may be impressed by the return of growth towards the end of the century. Finally, the switch to a pro-natalist population policy in Turkey is discussed in the light of the quantitative results.

For all three issues, the inspirations originate mainly from Golosov et al. (2007) who extend the concept of Pareto efficiency, for the first time, into environments with endogenous population growth in a satisfactorily general way. Of their main interest are efficiency concepts that do and do not consider the welfare of the unborn generations. Their main results are (*i*) that the dynastic model of endogenous fertility by Barro and Becker (1989) leads to efficient population in general and (*ii*) that non-pecuniary externalities result in violations of the (revised) first fundamental theorem of welfare economics.

6.1. The Intergenerational Conflict

The ITP scenario's optimism results in a level of output per capita that is around 35% higher than its benchmark in 2090 if the births per capita shifts permanently to a constant; see Figure 9.[33]

To frame the discussion here, consider two representative individuals, A and B, such that the individual A's age is $a > 0$ at 2045—when output per capita relative to its benchmark is the lowest—and that the individual B's age is $a > 0$ at 2090—when output per capita relative to its benchmark is the highest within the model horizon.

In spirit of Golosov et al. (2007), the individual A's welfare *loss* in 2045 for the individual B's welfare *gain* in 2090 cannot be supported as Pareto-dominating relative to the benchmark without a carefully constructed micro-founded model of endogenous fertility, and, furthermore, the question is to a large extent empirical since nothing ensures *a priori* that the particular theoretical model constructed is a good enough description of reality.

6.2. The Congestion Effects

Individuals A and B in the above discussion lose or gain welfare *regardless of the population level*. In reality, with a dependent population of around 120 million—which corresponds to a total population of around 250 million—in 2090, the individual B

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[33] According to the spirit of the model economy, this is basically due to a very large number L_{Nt} of the total Entry workforce—with the total working-age population in 2090 being close to 130 million—since the total R & D workforce is thinly distributed among the increasing number of firms.

would likely to be adversely affected by the congestion effects of a very high level of population.

The congestion effects are most important in the consumption of pure public goods with non-rivalry and non-excludability from the perspective of Pareto efficiency. The main question is whether the systems of health care, education, and social security, and other spheres where public goods such as the infrastructure are enjoyed will be ready to carry the heavy burden of a dependent population of 120 million. Would not such a level of dependency pose a threat to the well-being of the individual B and those in other ages in 2090 if the positive externalities due to the economies of scale had already been expended? Would the individual B really choose to have a Maserati or a Ferrari that she could *not* use to commute due to some excessive traffic jam? According to Golosov et al. (2007) who put forward these ideas using the example of pollution, such global negative externalities of overpopulation simply lead to Pareto inefficiency.[34]

An illuminating work on the congestion effects of a higher level of population is provided by the National Research Council (1986, Ch. 9). The conclusion there simply reads

> When negative [population] externalities exist, a minimum policy prescription [for a developing economy] would include the subsidized provision of family planning services to allow couples to achieve their desired levels of fertility. (p. 84)

6.3. The Pro-Natalist Population Policies

The last task in this section is to briefly discuss the merits of pro-natalist population policies.[35] The pro-natalist population policy is an important issue in itself given the pro-natalist rhetoric in Turkey and the implementation of pro-natalist policies by many European countries.

Very recently, Turkish Deputy Prime Minister Babacan declared in a televised interview[36] that

> Mr. Prime Minister has instructed me to lead efforts with all other related ministries. We need to implement some very smart measures. We need a well-outlined plan that would take into account possible effects on budget balances.

We do not know which "very smart measures" can or will be adopted. According to the United Nations (2011), countries use a variety of measures such as "baby

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[34] Overpopulation also leads to lower real wages for the property-less workers in other setups, but this is not necessarily Pareto-inefficient since it is a pecuniary externality—see Golosov et al. (2007).

[35] Attar (2012)—in an invited and non-refereed paper—provides a non-technical discussion of the pro-natalist population policy for a general audience.

[36] Anadolu Agency, "Erdogan orders measures to ward off population decline," `http://goo.gl/AAQyh`, January 30, 2013.

bonuses, family allowances based on the number of children, extended maternity and paternity leave, subsidized child care, tax incentives, subsidized housing, flexible work schedules, and campaigns to promote the sharing of parenting and household work between spouses." However, the effectiveness of these policy measures on fertility rises is not clear. Goldstein et al. (2009) document that, even though policies seem to have positively affected fertility in Estonia, Lithuania (to some extent), and Russia (after 2007), (*i*) there were fertility rises with no major change in population policies (as in Spain before 2007 and Russia between 2004 and 2007) and (*ii*) policies in some countries had no effect on fertility rates (as in Singapore and Japan). RAND (2011, p. 75), regarding the effects of pro-natalist policies, states that "Policy matters, but probably only a little," while the attention is paid to Sweden and Nordic countries where

> a comprehensive long-term government effort to stimulate female labour participation, and gender equality in the workplace and the family,

goes along with very high total fertility rates in European standards.

Returning to the welfare economics of Golosov et al. (2007) with endogenous population growth, we are left with the serious task of understanding why, in a given country and at a given time period, the recorded fertility rates and the level of population is too low (or too high). Golosov et al. (2007, p. 1066) state that the argument based on the notion that the social benefit of high fertility exceeds its private benefit does neither explicitly point to any negative externalities of low population nor provides an explanation to why the (revised) first fundamental theorem of welfare economics would not hold. In other words, it is not easy to argue *a priori* that an economy does have a Pareto-dominating population growth path that would be achieved under some pro-natalist policy intervention. As Golosov et al. (2007, p. 1066) rightly put forward, without knowing the precise source of an inefficiency, a serious policy debate is impossible.

Bloom et al. (2010), after considering various channels through which population aging affects economic growth, propose five policies, and *the pro-natalist population policy is not one of them*. According to the authors, (*i*) governments should find ways to direct the old but healthy people to work, (*ii*) the investments to improve the health of the elderly should be reconsidered, (*iii*) policies should encourage labor force participation more generally, (*iv*) immigration would make a big difference, and, finally, (*v*) the reforms in the pay-as-you-go social security systems are to be implemented.

These ideas depict—to say the least—some serious doubts on the notion of an active government intervention to boost fertility rates. We do not really know how effective such interventions are in the first place, and we have no convincing theory on the welfare economics of population growth, as of today, that indicates that fertility in Turkey is too low to imply an efficient path of population level to the long run.

7. Concluding Remarks

The famous French sociologist August Comte is believed to have said "Demography is destiny!" From an economist's point of view that takes *scarcity* and *choice* seriously, it is not! Humanity, coming from a dark distant past of subsistence, short lives, and no invention, has been moving for the last 250 years or so to a state of growing material standards of living, longer lives, and sustained invention. Some nations forge ahead, some remain as the followers, and many others have not yet partially or fully joined the journey of economic development. Yet, responding to the increasing cost of reproduction and to decreasing mortality measures, most human populations have reduced their fertility rates. Investing less into the objects and the bodies and more into the intangible stocks such as knowledge and human capital has been the norm for many of those living in this planet. At the individual level, in fact, there is nothing really *destined* about marriage and fertility choices. Some choose to bring many babies to the world, and some choose to not. The age of marriage increases on average, and some prefers to remain childless.

The pro-natalist rhetoric that remains ignorant on the history and the theory of economic growth and demographic change does neither help resolve the problem of population aging nor provide a new insight other than the ones implied by ancient teachings such as "Be fruitful, and multiply!" The results provided in this paper show that, even if Turkey, in the coming decades, can successfully direct more and more working-age individuals into the jobs by which they create more useful knowledge, the upward shifts in fertility rates would result in a lower level of per capita income and consumption for many more decades until which per capita income and consumption exceeds their no-fertility-shift paths. This naturally brings us back to the issues of altruism and intergenerational conflict, but one needs to be very careful about the long-run implications of the baby booms: First, the aging of the population is inevitable, and nothing insures the Turkish economy against a *delayed crisis* of the retiring baby boom generations. Second, again under the most optimistic technological progress scenarios for Turkey, the congestion effects of a remarkably higher level of population are going to be extremely adverse in terms of welfare. The projections of per capita income and consumption do not take into account such consequences of the baby booms in health, education, and other spheres where citizens exploit public services.

We do not know whether there is going to be a switch in Turkey from the ignorant pro-natalist rhetoric to a serious population policy that has a broad social vision and long-run considerations. We also do not know what the governments in Turkey are going to do with respect to research policy in order to keep Turkey on the path of sustained technological progress. The view of unified growth theory—enriched with the lessons of endogenous growth and new political economy literatures—suggests that the best way of dealing with an aging population is to ensure that the systems of health care, education, and social security are ready for the increasing burden of dependents and that, with sound political and economic institutions, the engines of economic growth are working properly. According to the results of this paper, technological progress will be the major source of economic growth in Turkey throughout this century if it does not stop for some reason.

Unless distorted by a sizable baby boom in a late stage of the demographic transition, the aging of population comes only once to an economy, and, if there exists a stable path to a long-run growth equilibrium with an aging population, to design and to implement the policies that would lead the economy to converge to this path is possibly the wisest thing to do.

This paper does not build upon explicit individual and social welfare functions and provides no policy analysis. Neither the problem of low labor force participation rates nor the issue of high unemployment is explicitly incorporated. Much work on the issue of growth and demography in Turkey is thus left for future research. A tractable and reliable dynamic general equilibrium model with endogenous technological progress and endogenous fertility that we can utilize in the analyses of various pro-natalist and social security policies, for example, is highly desired.

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